

DIVERSITY AND COLONIZATION PATTERN OF LEAF-LITTER ARTHROPODS DURING EARLY STAGES OF DECOMPOSITION IN MT. MAKILING, LOS BANOS, LAGUNA

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ABSTRACT

Litter arthropod presence is considered important because their feeding activities facilitate nutrient cycling. However, studies to document the leaf litter arthropod community in the Philippines remains wanting. This pioneering study aimed to: 1) identify arthropod orders and families associated with leaf-litter during the early stages of decomposition; 2) measure abundance and diversity of these leaf-litter arthropods, and; 3) observe the pattern of colonization of these arthropods on decomposing leaf-litter. Two (2) 100g mixed leaf litter samples were collected every other week for 10 weeks (December 2010-February 2011). Arthropods extracted from leaf litter samples were sorted and identified. A total of 1650 individuals were classified to belong to 13 orders, namely: Acarina, Araneida, Blattodea, Collembola, Dermaptera, Hemiptera, Hymenoptera, Isopoda, Lepidoptera, Psocoptera, Trichoptera, Coleoptera and Diptera. The last two orders mentioned were the most family-rich. Cluster analysis for family composition and diversity showed four discernible clusters hypothesized to have been influenced by moisture content and rainfall. This however, remains as speculation until a follow-up study is done. Also, no distinct pattern of colonization was observed. However, initial and consistent leaf litter arthropod colonizers were recognized. These were Araneida, Blattodea, Coleoptera, Collembola, Diptera, Hemiptera, Hymenoptera and Trichoptera. Consistent colonizers were namely: Coleoptera, Diptera and Hemiptera.

KEYWORDS: abundance, Berlese-Tullgren funnel, secondary growth forest

INTRODUCTION

Litter decomposition in tropical rainforest ecosystems is achieved by way of fragmentation, leaching as well as catabolism. This process of conversion from organic to inorganic form is considered vital nutrient cycling process

(Molles, 2010). It is affected by three main factors, namely; the climate, the litter quality and the nature and abundance of the decomposing organisms (Melillo et al., 1989; Anu et al., 2009; Devi and Singh, 2009).

Apart from factors like climate and litter quality, arthropod presence has been identified as a critical component in the process of leaf litter decomposition (Braack, 1996; Devi and Singh, 2009). Micro-arthropods or litter arthropods for example, affect nutrient cycling through their daily feeding activities. Consumption of plant litter allows the return of nutrients back to the ecosystem (Abbott, 1989; Powers et al., 1998). However, although the litter arthropod community is evidently crucial during leaf litter decomposition, there is little known about the change in diversity and composition of these litter arthropods.

Litter arthropod studies in the Philippines have been few. Raros (1999) documented the abundance and diversity of mites associated with litter in a rice agro-ecosystem in Isabela. Litter-associated mite species were identified to belong to 4 suborders, 47 families and 81 genera. These were even further classified according to trophic categories, namely: 61 predators, 38 detritivores, 6 phytophages. Four mite species had undetermined feeding habits. Meanwhile, knowledge of the array of litter leaf arthropods in the forest ecosystems are limited to the ant studies of Samson, Rickart and Gonzales (1997) and the thesis of Daub (2002). Samson et al. (1997) observed that the pattern of diversity and abundance of ant species across elevation gradients was opposite of that of what is observed in mammals. On the other hand, Daub (2002) reported three arthropod orders associated with litter in a rainforestation system of Leyte. These orders were namely: Acarina, Collembola and Diptera. All these three orders were designated as the “detritivore-microbivore dietary type.”

This study aims to contribute to previously mentioned works on Philippine litter arthropods through the following specific objectives: 1) identify arthropod orders and families associated with leaf-litter during the early stages of decomposition; 2) measure abundance and diversity of these leaf-litter arthropods, and; 3) observe the pattern of colonization of these arthropods on decomposing leaf-litter.

MATERIALS AND METHODS

Description of Study Site. Permanent Field Laboratory Area 1 (PFLA 1) is a natural secondary forest under the supervision and management of the Makiling Centre for Mountain Ecosystems (MCME). It is found in steep slope within Molawin watershed at an elevation of 160 masl. This was the site where mixed leaf litter was collected. Possible plant species that comprised mixed litter samples were inferred from Lambio and Buot (2011). These possible plant

sources are: *Diplodiscus paniculatus*, *Endospermum peltatum*, *Celtis luzonica*, *Alstonia macrophylla*, *Anthocephalus chinensis*, *Artocarpus blancoi*, *Calophyllum blancoi*, *Chisocheton pentandras*, *Dendrocnide meyeniana*, *Dracontomelon dao*, *Ficus ampelas*, *Litsea garciae*, *Parashorea malaanonan*, *Pterocymbium tinctorium*, *Strychnos multiflora*, *Swietenia macrophylla*,.



Figure 1.Dimensions of the experimental set-up.



Figure 2. Actual picture of the experimental set-up.

Set-Up of Experimental Area. A two meter by two meter area within the study site was cleared through sweeping. Previously accumulated plant litter materials in the area were removed, leaving behind an area ready for the deposition of newly-fallen leaf litter. The area was then divided into 16 squares measuring 0.5 meters by 0.5 meters. This area was delineated by plastic twine.

A total of 1.6 kilograms of mixed fresh leaf litter that had been forcefully detached after a typhoon was collected at the experiment site. Mixed leaf litter are newly fallen foliage from different plant sources. One hundred (100) grams was subsequently laid out in each of the 16 squares set up. A nylon net cover was also placed above the experimental area in order to avoid deposition of additional leaf litter during the duration of the study. Two (2) 100 gram samples were randomly collected in the experimental area every other week for 10 weeks. Sampling time was limited to 10 weeks because of limited leaf litter material and the short life span of litter arthropods being observed. Collected samples were weighed before being placed in the Berlese-Tullgren funnel for 48 hours. The resulting dried litter samples were weighed again thereafter. Fresh and dry weight of litter was recorded so that the percent moisture content can be computed as follows:

$$\% \text{ Moisture Content} = \frac{\text{fresh weight} - \text{dry weight}}{\text{fresh weight}} \times 100$$

Identification and Analysis. Extracted arthropods from the Berlese-Tullgren funnel were sorted and counted. Whenever possible, identification was done up to family level using Mackerras 1970 and Stehr 1998. The latter was mainly used to identifying immature insects.

The analysis software Biodiversity Pro ver. 2.0 was used to derive diversity index values at 2nd, 4th, 6th, 8th and 10th week of sampling. The same program was employed to conduct cluster analysis on abundance and diversity of arthropod families at each sampling period. This was done to see if there are any emerging patterns of colonization of these leaf-litter associated arthropod families.

RESULTS AND DISCUSSION

Leaf Litter Arthropods Abundance and Diversity. This preliminary survey of arthropods associated with early stage leaf decomposition yielded a total of 1650 individuals after the whole sampling period of 10 weeks. Total arthropod collections were composed of individuals of varying developmental stages and sexes (e.g. adults, immatures, males and females). Regardless of variation in development stage and sex, these arthropods were determined to represent 13 orders and 51 families. The 13 orders collected from the litter samples were namely: Acarina, Araneida, Blattodea, Coleoptera, Collembola, Dermaptera, Diptera, Hemiptera, Hymenoptera, Isopoda, Lepidoptera, Psocoptera and Trichoptera. Of these orders, Coleoptera (12 families) and Diptera (9 families) are the most family-rich orders. Table 1 is by far the first known listing of arthropod families associated with leaf litter during the first 10 weeks of decomposition in the Mt. Makiling forest reserve. Details of the guilds that these arthropod families form are made available in a separate paper.

Table 1 and Figure 3 show the total abundance of individuals every two weeks for 10 weeks. The largest recorded number of individuals was noted in during the 6th week (622) > 2nd week (368) > 8th week (340) > 10th week (165) > 4th week (155). Meanwhile, the two families that had the most number of individuals are the dipteran families, Scatopsidae (809) and Cecidomyiidae (146). Members of both families are known as either scavengers or detritivores (Mackerras, 1970; Stehr, 1998). Their high numbers was probably due to their attraction to the fermented products of decaying leaf litter as these sponging detritivores fed on these liquids. At this point in the decomposition process, leaf litter start to ferment causing scatopsids and cecidomyiids to aggregate in order to feed. They use they sponging mouthparts to absorb their liquid food. Some dipterans have been known to lay their eggs on fermented material (Romoser and Stoffolano, 1994) but since no immature forms were collected during the survey, the presence of these families were accounted to ther attraction to liquid food. On the other hand, the least abundant arthropods were mainly mites and

spiders. The presence of these arthropods could be temporal because of their nature as opportunistic predators.

Table 2 shows the ranges of diversity values reflected by the different indices of diversity used (i.e. Shannon Index of Diversity [H'], Shannon Index of Evenness[J], Simpson's Index of Diversity[1-D] and Simpson's Reciprocal Index[1/D]). The week with the highest diversity was week 4 > week 2> week 10> week 8 > week 6 (Table 2). With reference to Table 1 and Figure 3, week 4 also yielded the lowest individual counts. These very low counts may have been due to the heavy rains at the time of sampling. The heavy rains seem to have deterred many arthropods from staying in the leaf-litter but this may not have been the case for moisture-loving springtails (order Collembola) whose numbers distinctly increased in week 4. The other arthropods may have either searched for drier places to stay or were washed off by rainwater.

Shannon Index of Diversity (H') values ranged from 0.627 (6th week) to 1.401 (week 4). The lowest values were again recorded for week 6 for the indices such as the Shannon Index of Evenness (0.474), Simpson's Index of Diversity (0.536) and Simpson's Reciprocal Index (2.156). Meanwhile, the highest values for J (0.915), 1-D (0.957) and 1/D (23.31) was noted in week 4. Cluster analysis using the Bray-Curtis similarity index for family composition and diversity showed four noticeable clusters (Figure 4): Cluster 1- week 4 was entirely separate from weeks 2,6,8 and 10; Cluster 2- week 2 formed independent cluster from weeks 6,8 and 10; Cluster 3- week 10 formed independent cluster from weeks 6 and 8; Cluster 4- weeks 6 and 8 formed one cluster.

Table 3 reveal that week 4 was least similar to week 6 (14.16%). Week 4 showed highest similarity to week 10 (28.75%). Common arthropod families in weeks 4 and 10 belong to 8 orders, namely: Coleoptera (Colydiidae, Chrysomelidae, Hydrophilidae, Staphylinidae); Collembolla (Entomobryidae);

Table 1. Abundance of the individuals comprising different arthropod families per age of litter.

Order	Family	Abundance per Age of Leaf Litter (weeks)					Total Number of Individuals per Family
		2	4	6	8	10	
Acarina	Unknown 1	0	6	0	0	0	6
Araneida	Gnaphosidae	0	3	0	0	0	3
	Heteropodidae	2	1	0	0	0	3
	Salticidae	1	0	0	0	0	1

Blattodea	Blaberidae	1	2	1	0	0	4
Coleoptera	Bostrichidae	0	0	0	1	0	1
	Colydiidae	0	2	0	0	1	3
	Chrysomelidae	1	4	20	1	1	27
	Curculionidae	0	0	0	6	0	6
	Elateridae	0	3	0	0	0	3
	Histeridae	0	1	0	0	0	1
	Hydrophilidae	5	4	4	21	6	40
	Lathridiidae	0	1	0	0	0	1
	Leoididae	1	0	0	0	0	1
	Mordellidae	4	5	0	0	0	9
	Platypodidae	1	1	0	0	0	2
	Staphylinidae	4	9	17	11	7	48
	Unknown 2	2	1	0	0	0	3
	Unknown 3	1	4	0	0	0	5
Collembola	Entomobryidae	0	10	2	0	1	13
	Isotomidae	1	0	4	2	0	7
	Poduridae	1	15	0	0	0	16
	Sminthuridae	7	0	0	0	0	7
Dermaptera	Forficulidae	0	4	0	0	1	5
Diptera	Drosophilidae	0	0	16	11	3	30
	Cecidomyiidae	90	5	30	14	7	146
	Clusiidae	16	2	25	3	0	46
	Phoridae	41	6	0	2	0	49
	Psychodidae	73	4	15	2	0	94
	Scatophagidae	20	3	3	3	5	34
	Scatopsidae	63	13	419	214	100	809
	Simuliidae	0	0	0	0	2	2
	Xylophagidae	0	0	0	2	0	2
	Unknown 4	0	10	1	0	0	11
Hemiptera	Cicadellidae	11	12	0	0	0	23

	Cixiidae	0	0	1	7	0	8
	Delphacidae	1	0	35	0	7	43
	Meenoplidae	9	3	12	15	9	48
	Miridae	3	8	2	1	0	14
	Reduviidae	0	1	0	0	0	1
	Unknown 5	1	3	0	2	0	6
	Unknown 6	0	0	0	1	0	1
Hymenoptera	Braconidae	2	5	1	15	4	27
	Chalcididae	1	0	0	0	0	1
	Formicidae	2	1	10	4	7	24
Isopoda	Unknown 7	0	2	0	0	1	3
Lepidoptera	Pyalidae	0	1	0	1	1	3
Psocoptera	Unknown 8	0	0	1	0	0	1
	Hydropsychidae	0	0	0	0	1	1
Trichoptera	Unknown 9	1	0	0	0	0	1
	Unknown 10	2	0	3	1	1	7
Total Number of Individuals		368	155	622	340	165	1650

Table 2. Diversity indices at different sampling periods or leaf litter age.

Index	Week 2	Week 4	Week 6	Week 8	Week 10
Shannon Index of Diversity (H')	1.002	1.401	0.627	0.709	0.734
Shannon Index of Evenness (J)	0.679	0.915	0.474	0.521	0.574
Simpson's Index of Diversity (1 – D)	0.854	0.957	0.536	0.593	0.623
Simpson's Reciprocal Index (1 / D)	6.850	23.31	2.156	2.456	2.650

Dermaptera (Forficulidae); Diptera (Cecidomyiidae, Scatophagidae, Scatopsidae); Hemiptera (Meenoplidae); Hymenoptera (Braconidae, Formicidae); Isopoda (unknown 7); and Lepidoptera (Pyralidae).

Week 2 was least similar to week 4 (27.92%) and shared highest similarity to week 10 (37.52 %). Hydrophilidae and Staphylinidae were two coleopteran

families common to weeks 2 and 10. The orders Diptera (Cecidomyiidae and Scatophagidae), Hemiptera (Delphacidae and Meenoplidae) as well as Hymenoptera (Braconidae and Formicidae) were also present. One unknown trichopteran family was determined to be present in both weeks.

Table 3. Percent similarity matrix for the clusters formed.

	Week 2	Week 4	Week 6	Week 8	Week 10
Week 2	*	27.92	31.31	32.20	37.52
Week 4	*	*	14.16	21.82	28.75
Week 6	*	*	*	59.25	38.37
Week 8	*	*	*	*	57.82
Week 10	*	*	*	*	*

Table 4. Per cent moisture of the collected leaf litter at different sampling periods or age of litter in weeks.

Age of Leaf Litter (weeks)	Per cent Moisture Content
2	48.68
4	50.12
6	35.44
8	35.68
10	40.91

Cluster 3 formed by week 10 had 57.82% similarity with week 8. Chrysomelids, hydrophilids and staphylinids were coleopterans common to weeks 8 and 10. Shared dipteran families on the other hand were, Drosophilidae, Cecidomyiidae, Scatophagidae and Scatopsidae. Meenoplidae, Pyralidae and unknown family 10 singly represented Hemiptera, Lepidoptera and Trichoptera, respectively. Lastly, braconids and formicids were shared hymenopteran families between week 10 and week 8.

Week 8 shared highest per cent similarity with week 6, around 59.25%. The most number families shared between these weeks (Cluster 4) belonged to Diptera. These were: Drosophilidae, Cecidomyiidae, Clusiidae, Psychodidae, Scatophagidae and Scatopsidae. The next most family-rich orders common to weeks 6 and 8 were Hemiptera (Cixiidae, Meenoplidae and Miridae) > Coleoptera (Chrysomelidae, Hydropilidae and Staphylinidae)> Formicidae (Braconidae and Formicidae)> Trichoptera (unknown family 10).

These discernible cluster formations may have been influenced by the moisture content (Table 4) of leaf litter at different age or stage in decomposition. Arthropods are assumed to be affected by moisture (i.e. presence of exocuticle), they have mechanisms that enable them to either tolerate or adjust to low moisture conditions. Physiologically, their excretory systems can efficiently reabsorb water from the food they consume and excrete dry feces when moisture is limiting. They can also excrete liquid feces when there is high moisture. Behaviorally, arthropods seek moist environments to avoid desiccation and even limited their activities to conserve water in their bodies (Romoser and Stoffolano, 1994). Again, week 4 had the highest percent moisture content because of heavy rains. This corresponds well with the findings of Devi and Singh (2009) whose study in a sub-tropical forest ecosystem in India showed micro-arthropod presence had positive correlation with moisture content (as well as rainfall).

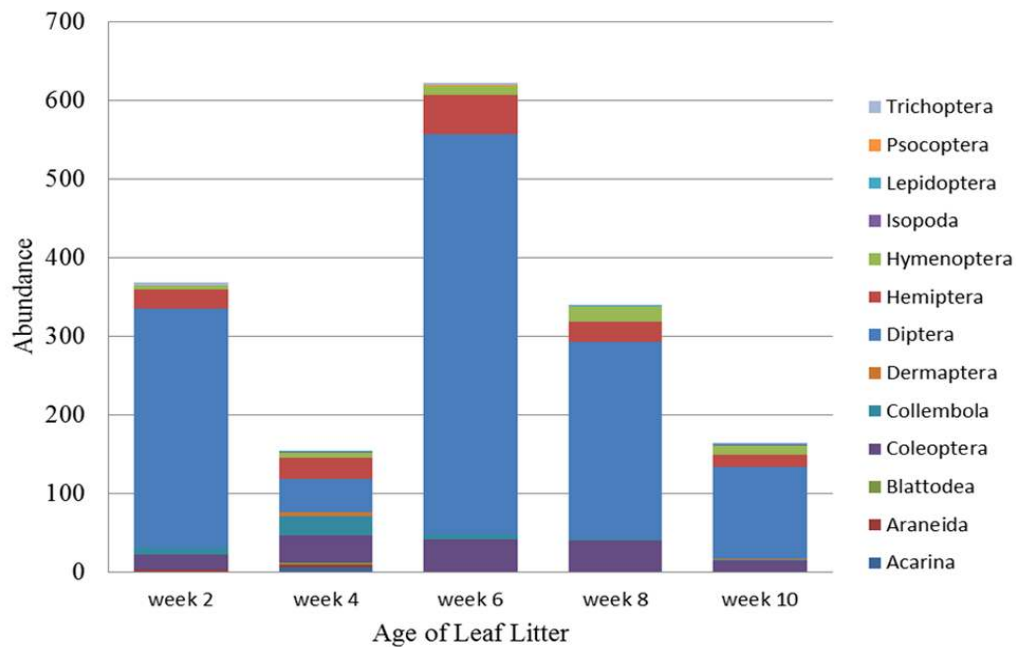


Figure 3. Abundance of arthropod orders from litter sampled every two weeks for 10 weeks.

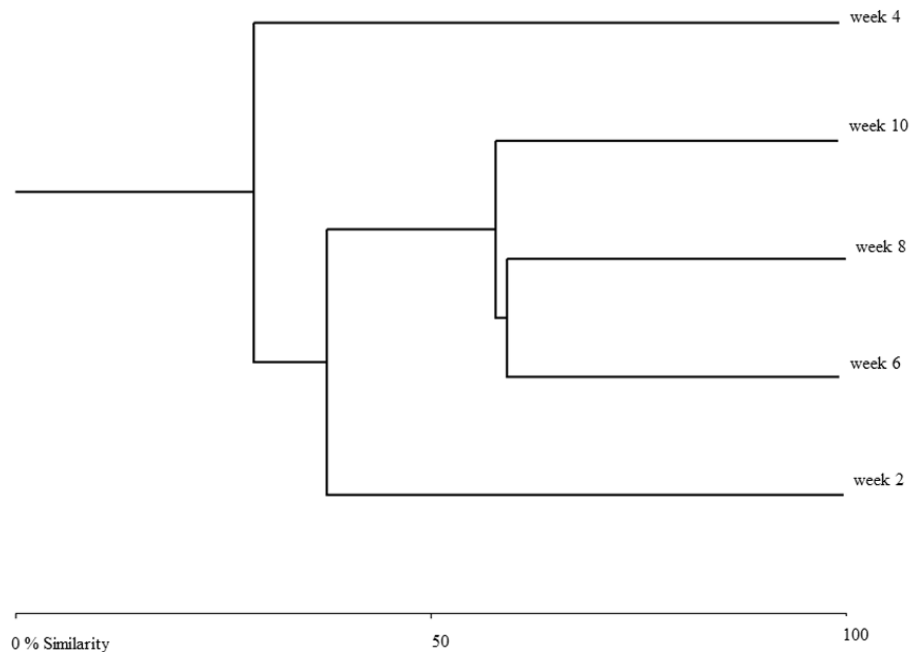


Figure 4. Cluster analysis using the Bray-Curtis similarity index for family composition and diversity.

Pattern of Arthropod Colonization. From the data presented in Figure 3, the first colonizers were determined to be from the orders: Diptera (303) > Hemiptera (25) > Coleoptera (19) > Collembola (9) > Hymenoptera (5) > Trichoptera and Araneida (3) > Blattodea (1). On the other hand, there were also arthropod groups that were consistently represented in the leaf litter extraction samples. The orders that were observed to be consistent colonizers were namely: Coleoptera (Chrysomelidae and Hydrophilidae); Diptera (Cecidomyiidae, Scatophagidae and Scatopsidae); and Hemiptera (Meenoplidae).

Arthropods present during the 10th week of sampling came from 9 orders and 19 families (with two unidentified families). These families are Colydidae, Chrysomelidae, Hydrophilidae and Staphylinidae (Coleoptera); Entomobryidae (Collembola); Forficulidae (Dermaptera); Drosophilidae, Cecidomyiidae, Scatophagidae, Scatopsidae and Simuliidae (Diptera); Delphacidae and Meenoplidae (Hemiptera); Braconidae and Formicidae (Hymenoptera); an

unknown family from order Isopoda; Pyralidae (Lepidoptera), Hydropsychidae and unidentified family (Trichoptera).

CONCLUSION AND RECOMMENDATIONS

The Mt. Makiling Forest Reserve has been the cauldron of various biological researches. However, these studies rarely explored the dynamics of leaf litter decomposition as affected by the presence arthropods. To bridge this information gap, a preliminary survey of leaf litter associated arthropods during the early stages of leaf litter decomposition was done. This 10-week sampling period yielded 1,650 arthropods representing 13 orders and 51 families.

Meanwhile, cluster analysis using the Bray-Curtis similarity index for family composition and diversity showed four discernible clusters with week 4 being distinctly separate from the rest of the sampling periods. It is hypothesized that the cluster patterns observed may have been due to the moisture content and rainfall. However, this still warrants further investigation (i.e. statistical correlation studies).

There was no distinct pattern of colonization observed. However, initial and consistent leaf litter arthropod colonizers were recognized. Initial leaf litter colonizers included- Araneida, Blattodea, Coleoptera, Collembola, Diptera, Hemiptera, Hymenoptera and Trichoptera. Meanwhile, consistent colonizers were namely: Coleoptera (Chrysomelidae and Hydrophilidae); Diptera (Cecidomyiidae, Scatophagidae and Scatopsidae); and Hemiptera (Meenoplidae).

This study only focused on the 10 weeks of leaf litter decomposition. Continuation of this study is highly recommended since decomposition process takes a lot longer to complete. Also, sampling period can be done during wet and dry seasons to determine if season has an effect on the abundance of leaf litter arthropods. If possible, all arthropods should be identified up to family level for characterization of their roles in litter decomposition.

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